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INVESTIGATIONS

Vol. 86 Washington: 1939 No. 3060

A REVISION OF THE TOADFISHES REFERRED TO PORICHTHYS AND RELATED GENERA

By Carl L. Hubbs and Leonard P. Schultz

In identifying a second species of *Porichthys* occurring along the coasts of southern California and Lower California, we found that the species referred to this American genus stand in need of revision. We have therefore studied all the material of these species in the United States National Museum, in the Museum of Zoology of the University of Michigan, and in the museum of Stanford University and have examined the pertinent literature, as the basis for the present paper. One new genus and two new species are described:

Aphos (for *Batrachus porosus* Valenciennes).
Porichthys myriaster (southern California and Lower California).
Porichthys analis (Gulf of California).

The toadfishes treated are those members of the family Batrachoididae having the following characters: 2 dorsal spines and 1 strong opercular spine, both solid and without connected poison glands; subopercle small, without spine; some of the teeth caninelike; no scales; *4 lateral lines*. With the exception of the Chilean and Peruvian *porosus*, here made the type of a distinct genus, *Aphos*, all species of this group have rows of many photophores (Greene, 1899) following the course of the multiple lateral lines. The presence of these organs is therefore not consistently associated with the increased number of the lateral lines and does not seem to furnish warrant for the separation of a family Porichthyidae, as proposed by Ribeiro (1915).

We separate another genus from *Porichthys*, recognizing *Nautopaedium* Jordan for *porosissimum*, the single, wide-ranging Atlantic species of the group. Thus *Porichthys*, with 5 or 6 species, is re-

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stricted to the Pacific coast, from southern Alaska to Colombia. Only *Porichthys notatus* occurs north of southern California and only *P. greenei* and *P. margaritatus* in the general vicinity of Panama. In southern California and on the outer coast of Lower California both *P. notatus* and *P. myriaster* occur. The center of abundance for the group seems to be the region of the Gulf of California and Cape San Lucas, where we find the northern *P. notatus*, the Panamic *P. margaritatus*, and apparently 2 or 3 additional forms, one of which is here named *P. analis*.

In distinguishing the species of *Porichthys*, we have found the number of anal rays to be particularly useful. Series of counts of anal rays have therefore been made and presented in table 1.

TABLE 1.—*Anal-ray counts of* Porichthys (*last ray counted as a double ray*)

Species and locality	Number of anal rays											Average
	27	28	29	30	31	32	33	34	35	36	37	
P. myriaster:												
Southern California							2	7	16	9	2	35.06
Lower California									1	1	1	36.00
P. notatus:												
British Columbia (Strait of Georgia)				1	4	2						31.14
Puget Sound			1	5	26	17	1					31.24
Central California					13	26	16	2				32.12
Southern California					4	22	10					32.17
Outer coast, Lower California				3	5	4	1					31.23
Gulf of California				1	2							30.67
P. species:												
Cape San Lucas, Lower California	1	2										27.67
P. analis										2		36.00
P. margaritatus:												
Lower California					4	2						31.33
Panama				7	19	4						30.90
Colombia				7	18	3						30.86
Galapagos Islands					1	1						31.50
P. greenei			1	2			4	7	2			32.50

ANALYTICAL KEY TO THE SPECIES OF PORICHTHYS AND RELATED GENERA

1*a*. Dorsal spines 2. Opercle with a single strong spine. Subopercle small, without a spine. Dorsal and opercular spines solid and without connected poison glands. Some of the teeth caninelike. Lateral lines 4. Scaleless.

2*a*. Photophores absent.

3*a*. Teeth of palatine and premaxillary not directed forward; those of palatine rather numerous and not confined to front of bone. *Peru and Chile*—— Aphos

4*a*. Dorsal and anal fin free from caudal. Pectoral fin pointed medially. Peritoneum white in adult. Lateral line organs, especially of dorsal and anal series, fimbriate—— Aphos porosus

2*b*. Photophores very numerous, developed in rows generally following the courses of lateral lines.[1]

3*b*. Teeth of palatine and premaxillary directed slightly backward in adults of both sexes; those of palatine numerous and not confined to front of bone. *Southern Alaska to Colombia*_____ Porichthys

4*b*. Dorsal and anal fin free from caudal. Pectoral fin pointed medially. Peritoneum blackish in adults. Lateral line organs, especially of dorsal and anal series, fimbriate. Photophores of minute size developed above and below some of the accessory dorsal lateral line organs.

5*a*. Branchiostegal rows of photophores with a U-shaped forward-directed commissure, not markedly constricted at base. Palatine teeth large, needle-shaped canines.

6*a*. Body with dusky dorsal saddles in young; becoming plain with age. Top of head unmarked. Dorsal fin usually more or less blotched with dusky. Anal fin definitely margined with dusky to blackish (except in young). Pleural row of photophores ending abruptly above end of second third of anal base, behind end of pleural lateral line. Anal rays 33 to 37, usually 34 to 36. Dorsal rays 36 to 38. *Southern California and outer coast of Lower California, close to shore*_____ Porichthys myriaster

5*b*. Branchiostegal rows of photophores united in a broad V, without forward projection. Palatine teeth small, somewhat compressed.

6*b*. Body with weak dorsal saddles in young, usually very weak; becoming plain with age. Top of head unmarked. Dorsal fin plain, or with a dusky edge, as a border or in spots. Anal fin more or less darkened, but usually without dark margin, or with a merely dusky border. Pleural row of photophores ending abruptly above end of second third of anal base behind end of pores and cirri of pleural lateral line. Anal rays 29 to 34, usually 31 to 33. Dorsal rays 33 to 36, usually 35. *Alaska to Cape San Lucas; in rather deep water south of Point Conception.* Porichthys notatus

6*c*. Body with 8 rather strong and persumably persistent, broad, light-brown dorsolateral bars, without light centers; without smaller, alternating spots. Top and sides of head unspotted. Dorsal fin with a row of 7 marginal light-brown blotches (separated by light areas from the body bars). Anal fin whitish, with a dusky brown border. Pleural row of photophores not ending above end of second third of anal base but continued backward (as smaller organs) nearly to end of fin; pleural lateral line (pores and strong cirri) extending to caudal fin. Anal rays 36. Dorsal rays 38 or 39. *Gulf of California*_____ Porichthys analis

6*d*. Body with strong and persistent dorsolateral blotches, often with light centers; with smaller, alternating spots in adult. Top and sides of head (and humeral region) definitely spotted with dark. Dorsal fin with a row of marginal black spots or blotches. Anal fin white or dusky to margin. Pleural row of photophores not

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[1] The arrangement of the photophores of *Porichthys* is described and figured in great detail and accuracy by Greene (1899), whose account was abstracted by Jordan and Evermann (1898, pp. 2317–2318) and partly quoted by Jordan (1905, vol. 1, pp. 190–197).

ending above end of second third of anal base but continued backward (as smaller organs) nearly to end of fin; pleural lateral line (pores and weak cirri) extending almost or quite to caudal fin. Anal rays 30 to 32. Dorsal rays 31 to 36. *Pacific coast of Tropical America, from Gulf of California and Cape San Lucas to Colombia*_____ Porichthys margaritatus

4*c*. Dorsal and anal fin joined to caudal. Pectoral fin rounded. Peritoneum white in adult (adult very small). Lateral line organs usually simple pores. Photophores absent just above and below accessory dorsal lateral line organs.

5*c*. Branchiostegal rows of photophores uniting in a broad V, from the point of which a short median branch extends forward. Palatine teeth somewhat compressed.

6*e*. Body with 6 large, persistent, solid, blackish saddles; without alternating smaller spots. Top of head crossed by a definite blackish bar. Dorsal and anal fins whitish, unmarked. Pleural row of photophores ending above middle of anal fin, but pores of pleural lateral line continued to caudal. Anal rays 29 to 35. Dorsal rays 32 to 38. *Pacific coast of Panama*___ Porichthys greenei

3*c*. Teeth of palatine in the adult of both sexes and the posterior premaxillary teeth in adult male directed forward; those of palatine few (usually 3 to 6) and confined to front of bone. *Atlantic coast from Virginia to Argentina (except West Indies?)*_____ Nautopaedium

4*d*. Dorsal and anal fin free from caudal. Pectoral fin pointed medially. Peritoneum white in adult. Lateral line organs fimbriate. Photophores of minute size developed above and below accessory dorsal lateral line organs.

5*d*. Branchiostegal rows of photophores with a U-shaped forward-directed commissure noticeably constricted at base. Palatine teeth very large, needle-shaped canines.

6*f*. Body sometimes plain, but usually with a row of dorsolateral spots and another row along dorsal base (the 2 rows often connected in young). Top of head plain or dark-spotted. Dorsal fin with 3 rows of small spots (spots sometimes fused into streaks, or lacking). Anal fin margined with dark. Pleural row of photophores ending above end of second third of anal base, but pleural lateral line continued to end of anal fin. Anal rays 31 to 35. Dorsal rays 33 to 38_____ Nautopaedium porosissimum

Bibliographic references of prime systematic importance are starred in the synonymies and in the bibliography. In the synonymies we attempt to give an analysis of the literature as it relates to the nomenclature, distribution, and general biology of each species treated, but do not refer to bare lists or to copied statements of locality or distribution.

APHOS, new genus

Orthotype.—Batrachus porosus Valenciennes.

In agreement with the very plausible suggestion made by Thompson (1916, p. 468), we erect this new genus for the sole reception of *Porichthys porosus* (Valenciennes), because this species alone among

all those referred to *Porichthys* lacks the complex photophores (Greene, 1899) so characteristic of the group. The photophores in *Aphos* seem to be totally lacking, despite the statement by Evermann and Radcliffe for the type of *Porichthys afuerae* (which we regard as a synonym of *Aphos porosus*) that "the lines of phosphorescent organs are essentially the same as in *P. margaritatus*, but much smaller and less clearly defined, in some places being almost invisible." Presumably these authors were confusing the pores and the photophores, for the type of *afuerae* shows no photophores.

In other respects, so far as apparent, *Aphos* agrees with *Porichthys*, as that genus is here defined, but the one distinction is regarded as fully sufficient for generic separation. We do not, however, agree with Ribeiro (1915) in regarding the characters as of family significance.

The one species of *Aphos* occurs in Peru and Chile, where it is the only representative of the *Porichthys* group.

Aphos, from ἀ, without + φῶς, light.

APHOS POROSUS (Valenciennes)

Batrachus porosus *Valenciennes, *in* Cuvier and Valenciennes, 1837, pp. 506–507, pl. 368 (original description).—Gay, 1848, p. 296 (Valparaiso).

Porichthys porosus *Girard, 1855a, p. 141 (new combination).—*Günther, 1861, p. 177 (description).—*Jordan, 1884b, p. 41 (teeth).—*Meek and Hall, 1885, pp. 55, 56 (diagnosis, synonymy).—Reed, 1897, p. 661 (Valparaiso).—Steindachner, 1898, p. 306 (Iquique, Chile).—Delfin, 1901, pp. 89–90 (synonymy, records).—Fowler, 1916, p. 65 (Valparaiso).—Thompson, 1916, pp. 456, 458 (Tome, Chile). (Type locality: Valparaiso, Chile.)

Batrachus chilensis *Gay, 1848, p. 297 (original description).—Reed, 1897, p. 661. (Type locality indicated only by name of species.)

Porichthys afuerae *Evermann and Radcliffe, 1917, pp. 152–153, pl. 14, fig. 1 (original description). (Type locality: Lobos de Afuera, Peru.)

The examination of new material (table 2) fails to confirm Evermann and Radcliffe's (1917) separation of a larger-headed Peruvian species (*afuerae*) from the typical, Chilean *porosus*. These authors indicated that the length of the head in the types of *afuerae* enters the standard length 3 times and the total length 3.6 or 3.41 times (two statements), whereas in *P. porosus* the head is contained 4.66 times in the total length, according to Günther.

In addition to the fishes listed in table 2, we have examined the following material, all very small specimens collected by Dr. W. L. Schmitt in Peru, during January 1935: U.S.N.M. no. 101722 (18 specimens), Afuera, Lobos Islands, North Bay, 12 fathoms, January 17; nos. 101723 (1 specimen) and 101724 (8 specimens), all from Afuera, Lobos Islands, South Bay, 14 to 16 fathoms, January 17;

no. 101720 (2 specimens), Independencia Bay, clean sand bottom at 3.5 fathoms, January 14; no. 101721 (1 specimen), Callao, January 11. The lack of photophores in these specimens is definitely appreciable.

TABLE 2.[3]—*Measurements of the head in specimens of* Aphos porosus *from Peru and Chile*

Locality	In hundredths of standard length								
	27	28	29	30	31	32	33	34	35
Peru	------	2	2	2	6	2	1	------	----
Chile	2	------	------	1	------	------	------	1	1
Uncertain locality	------	------	3	------	------	------	------	------	----

[3] The data in this table were taken from specimens bearing the following U.S.N.M. numbers: 77382, Tome, Chile; 77383, locality ?; 77552 (type of *P. afuerae*), Lobos de Afuera, Peru; 88808, Lota, Chile; 101719, north shore of Middle Chincha Island, Peru; 102048, Independencia Bay, Peru; and 103432, locality ?; and Stanford University no. 22680, Tome, Chile. In addition, 12 specimens from San Juan and Independencia Bays, Peru, collected by the 1938 Hancock Expedition, are recorded through the courtesy of Dr. George S. Myers. The lengths of all specimens range from 19.9 to 222 mm.

Genus PORICHTHYS Girard

Porichthys *GIRARD, 1855a, p. 141 (original description); 1858, p. 134 (description).—*GÜNTHER, 1861, pp. 175–176 (description).—*KNER, 1865, pp. 189–190 (description).—*JORDAN and GILBERT, 1883a, pp. 750–751 (diagnosis, type designation).—*MEEK and HALL, 1885, pp. 52, 55–57 (description, review of species).—*JORDAN and EVERMANN, 1898, pp. 2317–2323 (description, description of lateral line and pore structure quoted from Greene, analysis and description of species).—BEAN and WEED, 1910, pp. 514, 515, 525 (comparison).—RIBEIRO, 1915, p. — (description, type of new family).—MEEK and HILDEBRAND, 1928, pp. 910, 922 (diagnosis, *Nautopaedium* a synonym).

Type.—"*Porichthys notatus* Grd.=*Batrachus porosissimus* C. & V." (designated by Jordan and Gilbert, 1883a, p. 751).

The species of *Porichthys* are compared in the preceding key and in tables 1 and 3.

PORICHTHYS MYRIASTER, new species

FIGURE 57, *b*

Porichthys notatus (misidentifications) YARROW and HENSHAW, 1878, p. 202 (color).—JORDAN and EVERMANN, 1898, pp. 2321–2322 (synonymy, description; in part).—STARKS and MORRIS, 1907, pp. 230–231 (color, range, and habitat; in part).—STARKS and MANN, 1911, p. 16 (bathymetric distribution; in part).—OSBURN and NICHOLS, 1916, p. 177 (records for bays on outer coast of Lower California, identifications presumptive).—HUBBS, 1920, p. 380 (bionomics; in part).—GREENE and GREENE, 1924, pp. 501–506, fig. 1 (San Pedro Harbor record, phosphorescence; good figure).—BARNHART, 1936, pp. 92–93 (diagnosis; in part), fig. 281.

Porichthys porosissimus (misidentifications) JORDAN and GILBERT, 1880, p. 25 (San Diego; in part).—BEAN, 1880, p. 83 (records; in part).—JORDAN and GILBERT, 1881a, p. 454, and 1881b, p. 65 (records; in part); 1883a, pp. 751–752 (description; in part).

Porichthys margaritatus (misidentifications) JORDAN and GILBERT, 1882b, p. 291, and 1883a, p. 958 (in part); JORDAN, 1884b, p. 41 (range and synonymy; in part); 1885b, p. 116 (in part).—MEEK and HALL, 1885, p. 56 (synonymy; in part).—EIGENMANN, 1892, p. 171 (in part).

As indicated in the key, this heretofore unrecognized species differs from *P. notatus* (and from all other species here retained in *Porichthys*) in the U-shaped forward-directed commissure of the branchiostegal rows of photophores (compare fig. 57, *b* and *c*); in the larger, more needlelike palatine teeth; typically in the more conspicuous dorsal saddles and more blotched dorsal fin (these juvenile traits tend to disappear with age but are more persistent in *myriaster* than in *notatus*); and in the definitely dark-margined anal fin (the young have the fin clear). The distinctness of *myriaster* from *notatus* is proved by the higher number of anal rays, for there is little overlap in the counts (table 1). The corresponding difference in number of dorsal soft rays (table 3) is not quite so sharp.

Porichthys myriaster also shows a habitat distinction from *P. notatus*, although its entire range is overlapped by that of *notatus*. Along the coasts of southern California and Lower California *myriaster* is the characteristic form of the muddy and sandy bays, and along the open shore it tends to live in shallower water than *notatus*. The difference in bathymetric range is partly obscured by the tendency of the young of *notatus* to mingle with *myriaster* in rather shallow water (to 25 fathoms). The only specimen of *myriaster* known from water deeper than 25 fathoms is one adult taken at 69 fathoms.

P. myriaster apparently does not share with *P. notatus* the habit which that form exhibits (in the cooler portion of its range) of migrating into the intertidal zone of the rocky reefs for spawning (Hubbs, 1920). The very few records of *Porichthys* approaching or entering this zone in southern California probably refer to *P. notatus*. *P. myriaster* is apparently more of a bay and less of a reef inhabitant.

The holotype of *Porichthys myriaster* (U.S.N.M. no. 8483) is an adult 306 mm in standard length and 347 mm in total length, collected by Cassidy at San Diego. It is apparently not the specimen (U.S.N.M. no. 694) recorded as *Porichthys notatus* by Girard (1858) as taken by Cassidy at San Diego, for that fish was also found.

Description of holotype.—Dorsal, II–36; anal, 33; pectorals 20–20; pelvics I, 2. Gill rakers on lower part of first arch 17. Palatine teeth caninelike, curved backward, 9 in the single series on each side; vomerine canines 1 or 2 at each outer angle of bone, very strong, curved backward; premaxillary teeth conical, strong, uniserial;

mandibular teeth conical, strong, biserial at front of jaw with the inner row continued backward as canines. Peritoneum blackish. The coloration of head, body, and fins is described in item 6*a* of the key (p. 475).

Measurements in thousandths of the standard length for the holotype and (in parentheses) for 9 paratypes 53 to 304 mm long: Greatest depth, 173 (163–219); distance from tip of snout to origin of soft dorsal, 353 (328–366); to origin of spinous dorsal, 281 (260–300); from tip of chin to anus, 451 (385–430); length of head, 286 (270–310); interorbital width, 88 (68–95); length of orbit, 36 (36–60); of upper jaw, 150 (140–159); of snout, 78 (64–87); distance from tip of lower jaw to anteriormost point of the U-shaped forward extension of the branchiostegal row of photophores, 62 (47–62); between the nearly parallel ventral rows of photophores, 33 (23–33); from anus to anterior extension of ventral row of photophores, 199 (165–195); height of pectoral arch of pleural row of photophores, 38 (23–44); length of this arch, 118 (94–148).

Measurements of 9 paratypes 53 to 304 mm long, stepped into standard length: Greatest depth, 4.8–6.1; length of head, 3.2–3.7. Height of pectoral arch of the pleural row of photophores in length of arch, 2.8–4.2; least distance between ventral rows, 4.9–6.5 in distance from anus to anterior tip of that row; distance from tip of chin to anterior tip of branchiostegal row, 3.6–6.5 in head.

The following paratypes of *Porichthys myriaster* are deposited in the National Museum: U.S.N.M. no. 17046, Santa Barbara, Calif.; nos. 24814, 24863, 24881, 26805, 31349, 34757, 34777, 54738, 54748, 54749, 54757, 54760, 54764, and 62409, all from "San Diego" or San Diego Bay, Calif.; no. 103431, from latitude 32°34′30″ N., longitude 117°18′45″ W.

The following paratypes of *Porichthys myriaster* are deposited in the Museum of Zoology, University of Michigan: No. 63610, Anaheim Bay, Calif.; 64146, off Mira Mar Pier, Calif.; 64148, 34°21′20″ N., 119°31′20″ W.; 64149, 32°36′00″ N., 117°13′15″ W.; 86050 and 105489, Turtle Bay, Lower California; 80829, Magdalena Bay, Lower California; 115795, San Pedro, Calif.; 115820, from 34°17′20″ N., 120°13′00″ W.; 115821, Carpenteria to Rincon, Calif.; 115822, 34°27′30″ N., 120°11′20″ W.; 115823, 34°27′00″ N., 120°03′30″ W.

myriaster, from μῦριάς, myriad + ἀστήρ, star, referring to the multitudinous photophores, which when active shine like stars.

PORICHTHYS NOTATUS Girard

Porichthys notatus *Girard, 1855a, p. 141 (original description); 1855b, p. 151 (records); *1858, pp. 134–136 (description, records); *1859, p. 50, pl. 25 (diagnosis, figure of type).—Suckley, 1860, p. 356 (diagnosis; Fort Steilacoom, Puget Sound).—*Jordan and Starks, 1895, p. 840 (natural history;

distinct from *margaritatus*).—*Jordan and Evermann, 1898, pp. 2321–2322 (synonymy, description; in part).—*Greene, 1899, pp. 667–696 (photophores, range except Panama).—Jordan, 1905, vol. 1, pp. 190–197, figs. 146–148 (Greene quoted on photophores); vol. 2, p. 526.—Evermann and Goldsborough, 1907, pp. 224, 335 (Union Bay, British Columbia, not Alaska).—Starks and Morris, 1907, pp. 230–231 (color of young; Sitka to Gulf of California; in part).—Holder and Jordan, 1909, pp. 315–318 (noise, etc.).—Evermann and Latimer, 1910, p. 139 (records).—Starks and Mann, 1911, p. 16 (bathymetric distribution; in part).—(?) Metz, 1912, p. 41 (records, not verified).—Halkett, 1913, p. 109 (range, including British Columbia).—Kincaid, 1919, p. 40 (natural history; Puget Sound).—Bean and Weed, 1920, p. 79 (Ucluelet, Vancouver Island).—*Hubbs, 1920, p. 380 (bionomics; in part, but nearly all observations based on *notatus*).—Greene and Greene, 1924, pp. 500–506 (Monterey Bay; phosphorescence).—Schultz, 1936, p. 197 (range).—Schultz and DeLacy, 1936, p. 142 (record; Puget Sound).—Barnhart, 1936, pp. 92–93 (diagnosis; in part). (Type locality: ["South Fork" of] San Francisco [Bay], California.)

Porichthys porosissimus (misidentifications) Günther, 1861, p. 176 (records for Vancouver Island only).—Bean, 1880, p. 83 (records; in part).—Jordan and Gilbert, 1880, p. 25 (San Diego; in part); 1881a, p. 454 (records; in part); 1881b, p. 65 (habitat; in part).—Jordan and Jouy, 1881, p. 5 (records).—Jordan and Gilbert, 1883a, pp. 751–752 (description; in part).—Kermode, 1909, p. 89 (British Columbia).—Prince, 1910, pp. 1068–1069 (voice, parental care; name misspelled *porissimus*).

Porichthys margaritatus (misidentifications) Jordan and Gilbert, 1882b, p. 291 (in part); 1883a, p. 958 (in part).—Jordan, 1884a, p. 291 (Vancouver Island record only); 1884b, p. 41 (range and synonymy; in part); 1885a, p. 388 (in part); 1885b, p. 116 (in part).—*Meek and Hall, 1885, p. 56 (synonymy; in part).—Test, 1889, pp. 43–52, pl. 4 (photophores).—Eigenmann and Eigenmann, 1889a, pp. 32–34 (photophores); 1889b, p. 131 (eaten by rock cod, Cortez Banks).—Evermann and Jenkins, 1891, p. 162 (synonymy; in part; Santa Barbara record).—Eigenmann, 1892, pp. 126, 131, 171 (synonymy, egg, ecology; in part; Cortez Banks).—Bean and Weed, 1920, p. 79 (Vancouver Island).

Porichthys Fraser, 1921, p. 48 (intertidal reef, Strait of Georgia).

This species has a wide distribution, both geographically and ecologically. It ranges from Sitka in southern Alaska to the Gulf of California (Starks and Morris, 1907, p. 230) and occurs (as a variant race) almost as far south as Cape San Lucas. Bathymetrically its habitat extends from the intertidal zone to depths as great as 145 fathoms. It has generally been stated that this form lives in deeper water to the southward, but this seems true only in that it largely avoids the bays and shoals in the south. From the vicinity of Point Conception northward it freely migrates (Greene, 1899) into the intertidal zone to spawn but seldom enters this zone south of Point Conception (Hubbs, 1920). It is common in the bays from central California northward, whereas to the southward it is largely if not entirely replaced in the bays by *Porichthys myriaster*. It occurs in deep water in the north as well as in the south.

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In view of its wide geographic and bathymetric range, it is not surprising that *Porichthys notatus* exhibits considerable variation. The anal rays (table 1), averaging highest in California, decrease in average number both toward the north and the south. A marked backward extension of the pleural row of photophores was indicated by Greene (1899, p. 676) for Alaskan specimens, but some doubt is attached to the claim (see page 488). The race in the Puget Sound region is unusually heavy-set and dark. Specimens dredged in moderate depths off the outer coast of Lower California and in the Gulf of California differ from typical *notatus* not only in the slightly reduced number of anal rays but also in a slightly greater tendency for the retention into half-grown stages of the 6 or 7 dusky saddles, and in the more frequent and distinct tendency of the anal fin to become margined with dusky; they also average lighter in color. Occasionally one or a very few minute photophores may be discerned behind the normal termination of the pleural row.

The most aberrant individual that we have referred to *P. notatus* was dredged the farthest south, on the outer coast of Lower California not far north of Cape San Lucas. This specimen (U.S.N.M. no. 46675), a large young fish 82 mm in standard length, was dredged by the *Albatross* on May 1, 1888, at station 2830, in 66 fathoms, at latitude 23°33′ N., longitude 110°37′ W. Unlike the two doubtful forms described below, it has 33 anal and 36 soft dorsal rays. It differs distinctly from the types of *P. analis* in having fewer blotches on the back and on the dorsal fin, the margin of the anal fin darker, no cirri on the posterior pores of the pleural lateral line, and the head larger (3.4). The 6 large dark-brown dorsolateral blotches are more conspicuous than in *notatus* but less so than in *margaritatus*. The marginal blotches on the dorsal fin are quite unlike the continuous dark edging of *notatus* but are rather fewer and more elongate than in *analis* or *margaritatus*. The blackish-brown border of the anal fin is stronger than in any other specimen at hand of *notatus*. A few small photophores are present in the pleural row behind the main ones, and pores without developed cirri continue in the pleural row about to the end of the anal base.

In various respects the Lower California races of *P. notatus* show some approach toward *P. myriaster* and toward *P. margaritatus*. No intergradation between *notatus* and *myriaster* is indicated, however, for the distinction in the course of the branchiostegal row of photophores remains trenchant, and the difference in the number of anal rays is accentuated in Lower California (table 1). It is possible that intergradation with *P. margaritatus* will be discovered, since that species and *notatus* seem very closely allied. The interrelation between *margaritatus* and *notatus*, in the approximate region of the

overlap in their distribution, is complicated by the probable existence there of two additional forms of the same general type. These are discussed below as *Porichthys* sp. and *Porichthys analis*, new species.

The following collections of *Porichthys notatus* in the U. S. National Museum have been examined: U.S.N.M. no. 520, San Francisco Bay (type); 521, Presidio, Calif.; 523, Fort Steilacoom, Wash.; 694 and 103435, San Diego, Calif.; 4474, San Francisco, Calif.; 7536, Victoria, British Columbia; 26647, off Point Loma, Calif.; 26889, Santa Barbara, Calif.; 27277, Puget Sound, Wash.; 41878, Cortez Banks, Lower California; 46461, 34°12′30″ N., 120°32′30″ W.; 46462, 34° N., 120°23′ W.; 46476, 32°44′30″ N., 117°23′ W.; 46479, 24°24′30″ N., 111°53′ W.; 46481, 26°14′ N., 113°13′ W.; 46493, 32°34′30″ N., 117°18′45″ W.; 46494, 29°19′00″ N., 112°50′ W.; 46644, 28°07′00″ N., 111°39′45″ W.; 46675, 23°33′ N., 110°37′ W.; 46731, 29°40′ N., 112°57′ W.; 48572, 37°38′00″ N., 123°02′30″ W.; 53817, Bellingham, Wash.; 54500, 34°23′30″ N., 120°19′30″ W.; 54628, 37°06′40″ N., 122°37′30″ W.; 59399, 37°30′00″ N., 123°02′30″ W.; 59400, Comox, British Columbia,; 60582 and 60821, Union Bay, British Columbia; 60583, near Port Townsend, Wash.; 67313, San Pablo Bay, Calif.; 67314, San Francisco Bay, Point San Bruno; 70957, Union Bay, Bayne Sound, British Columbia; 75459, Pacific Grove, Calif.; 75607 and 75608, off Point Pinas Light, Calif.; 75610, off La Jolla, Calif.; 77979, 33°17′00″ N., 118°24′00″ W.; 82155, Ucluelet, British Columbia; 83971, Union Bay, east of Coal Wharf, British Columbia; 101400, Dillon Beach, Calif.; 102286, Santa Barbara or Santa Barbara Islands.

The following collections of *Porichthys notatus* in the Museum of Zoology, University of Michigan, have been examined: Nos. 56332 and 63608, from Monterey Bay, Calif.; 61695, between Avila and Pismo, Calif.; 61696, Mussel Point, Pacific Grove, Calif.; 61697, near Piedras Blancas, Calif.; 63601, 63602, 63604, 63607, and 63609, all from San Francisco Bay, Calif.; 63603, near Point Reyes, Calif.; 63605, Elkhorn Slough, Calif.; 63606, off Del Monte, Calif.; 64145, 34°27′30″ N., 120°11′20″ W.; 64147, 34°27′00″ N., 120°03′30″ W.; 64148, 34°21′20″ N., 119°31′20″ W.; 64150 and 64151, off Long Beach, Calif.; 64152, Carpenteria to Rincon, Calif.; 64153, lat. 34°17′20″ N., long. 120°13′00″ W.; 64154, off San Pedro, Calif.; 92602, Drakes Bay, Calif.; 94012–94017, all from Hoods Canal, near Holly, Wash.; 115796, Puget Sound, Everett, Wash.

The following collections of *Porichthys notatus* in the Natural History Museum of Stanford University have been examined: No. 91, 34°18′30″ N., 119°41′ 00″ W.; 5050, 37°06′00″ N., 122°32′00″ W.;

5191, 37°13′50″ N., 122°32′30″ W.; 5192, 37°44′50″ N., 122°43′00″ W.; 5211, 35°40′30″ N., 121°22′40″ W.; 5574, Pacific Grove, Calif.; 10700, San Francisco Market; 21341, San Juan Islands, Wash.; 32242, McNears Point, San Pablo Bay.

PORICHTHYS species

Porichthys margaritatus (presumably a misidentification) JORDAN and GILBERT, 1882c, p. 368 (record of specimens discussed below).

Three young specimens (U.S.N.M. no. 3004), 39.5 to 41.5 mm in standard length, collected by Xantus at Cape San Lucas, seem to represent an undescribed species of *Porichthys*. The anal rays are 27 in one and 28 in two, whereas only one other specimen of the genus examined (an example of *P. notatus*) has as few as 29 anal rays. The dorsal rays are correspondingly decreased (table 3). The specimens though poorly preserved show 6 large dusky dorsolateral blotches. The small photophores in the pleural row behind the main ones are rather numerous, at least on one side of one specimen (some are evident on the opposite side of this individual, and on the other specimens), but the condition of preservation does not permit it to be determined with certainty whether these small organs are as well developed as in *P. margaritatus*. Nor are the lateral line structures to be precisely determined.

TABLE 3.—*Dorsal rays in species of* Porichthys

Species	Number of dorsal rays									
	30	31	32	33	34	35	36	37	38	39
P. myriaster							4	5	7	
P. notatus				1	4	16	5			
P. species	2									
P. analis									1	1
P. margaritatus		1		3	2	3	2			
P. greenei			1	1	1	2	4	3	2	

The V-shaped branchiostegal row of photophores as well as the number of fin rays excludes these specimens from *P. myriaster*. The contrast in radial formula is greatest when these specimens are contrasted with the two types of *P. analis*. They agree rather well with corresponding young of either *notatus* or *margaritatus* and may represent aberrant examples or a subspecies of either form. The agreement is particularly close with the original figure and description of *Batrachus margaritatus* from the Gulf of Fonseca, and they may represent the true *margaritatus* if that form should be distinct from the one (*nautopaedium*) usually assigned the name.

The available specimens of this form are unfit to serve as the basis for the proposal of a new name. The examination of material newly collected about Cape San Lucas should solve its status.

PORICHTHYS ANALIS, new species

Two specimens of *Porichthys* from the Gulf of California present characters that indicate rather conclusively a specific difference from both *notatus* and *margaritatus*. They were dredged by the *Albatross* on March 24, 1889, at station 3017, in 58 fathoms, at latitude 29°54′30″ N., longitude 113°01′00″ W. The holotype, 95.5 mm in standard length and 108 mm over all, is cataloged in the National Museum as no. 46645. The one paratype, measuring 80 and 93.5 mm, is U.S.N.M. no. 106503.

In number of dorsal and anal rays (tables 1 and 3) *P. analis* agrees with *P. myriaster*, but it has the V-shaped branchiostegal row of photophores characteristic of *notatus* and its variants as well as *margaritatus*. When *analis* is compared with *notatus* the increased number of fin rays seems particularly significant in view of the apparent decrease southward (from California) in average number of rays. It differs further from *notatus* in having the pleural row of photophores as in *margaritatus* continued backward (as smaller organs) from the end of second third of anal base nearly to end of fin. Instead of ending before the end of the large organs of the pleural photophores, the pores and cirri of the pleural branch of the lateral line extend to the caudal fin. The pores in this extension of the pleural line are even stronger than in *margaritatus*. Further differences between *analis* and both *notatus* and *margaritatus* lie in the coloration of the body, head, and fins, as specified in items 6*b*, 6*c*, and 6*d* of the key (pp. 475–476).

Dorsal II–38 (II–39)[3]; anal 36 (36); pectorals 19–20 (20–20); pelvics I, 2. Gill rakers on lower part of first arch 16 (16). Palatine teeth caninelike, very slightly curved backward, 7 to 9 in the single series on each side, the anteriormost teeth strongest; vomerine canines 1 or 2 at each outer angle of bone; rather strong, very slightly curved backward; premaxillary teeth conical; mandibular teeth biserial anteriorly, with the inner row continued backward as strong canines. Peritoneum brownish black. The coloration of body, head, and fins is given in the key, under item 6*c* (p. 475).

Measurements in thousandths of the standard length: Greatest depth, 181 (195); distance from tip of snout to origin of soft dorsal, 324 (336); to origin of spinous dorsal, 268 (275); from tip of chin to anus, 372 (388); length of head, 273 (280); interorbital width, 65

[3] Items in parentheses are for the paratype.

(66); length of orbit, 58 (61); of upper jaw, 137 (150); of snout, 63 (73); distance from tip of lower jaw to tip of V of branchiostegal row of photophores, 81 (85); least distance between the nearly parallel ventral rows of photophores, 31 (37); from anus to anterior extension of ventral row of photophores, 156 (160); height of pectoral arch of pleural row of photophores, 42 (42); length of this arch, 88 (92).

It is possible that specimens of this species have been reported under another name. The material recorded from the Gulf of California by Jordan and Gilbert (1882a, p. 274), Evermann and Jenkins (1891, p. 162), and Breder (1936, p. 47) in particular should be reexamined with this idea in mind.

analis, pertaining to the anal (fin), with reference to the increased number of rays.

PORICHTHYS MARGARITATUS (Richardson)

FIGURE 57, *d*

Batrachus margaritatus *RICHARDSON, 1844, pp. 67–69, pl. 38, figs. 2–4 (original description).

Porichthys margaritatus *JORDAN and GILBERT, 1882b, pp. 291–292 (*notatus* a synonym; comparison); 1883a, p. 958 (in part); 1883c, p. 626 (Central America).—JORDAN, 1884a, p. 291 (Panama record; distinct from *porosissimus*); *1884b, p. 41 (range and synonymy; in part); 1885a, p. 388 (Panama); 1885b, p. 116 (in part).—*MEEK and HALL, 1885, pp. 55–57 (synonymy; in part; distinct from *porosissimus*).—EVERMANN and JENKINS, 1891, pp. 127, 162 (synonymy; in part; Guaymas record, not verified).—*JORDAN and STARKS, 1895, p. 840 (*notatus* distinct; *nautopaedium* a synonym).—*JORDAN and EVERMANN, 1898, pp. 2319, 2322–2323 (description, synonymy).—*GILBERT and STARKS, 1904, pp. 184–185 (Panama record).—*MEEK and HILDEBRAND, 1928, pp. 922–924 (synonymy, description).—BREDER, 1936, p. 47 (records, northern part of Gulf of California to Perlas Islands, Panama—perhaps in part based on other species).—KUMADA, HIYAMA, ARITA, TOMITA, and MURAMATSU, 1937, p. 57 (misspelled *margitatus*), pl. 41. (Type locality: Gulf of Fonseca, Pacific coast of Central America.)

Porichthys porosissimus (misidentification) *GÜNTHER, 1861, p. 176 (in part).—(?) JORDAN and GILBERT, 1882a, p. 274 (Gulf of California in 15 fathoms—record not verified); 1883a, pp. 751–752 (description; in part).

Porichthys notatus (presumed misidentification) BOULENGER, 1899, p. 3 (Rio Tuyra, Darien).—GREENE, 1899, p. 668 (Panama).

Porichthys nautopaedium *JORDAN and BOLLMAN, 1890, pp. 171–172, 182 (original description, records).—GREENE, 1899, pp. 668, 678 (photophores; name misspelled *nautopedium*). (Type locality: Pacific Ocean off coast of Colombia at *Albatross* station 2802, lat. 8°38′ N., long. 78°31′30″ W., in 16 fathoms.)

Some doubt is attached to the use of the name *margaritatus* for the species more recently named *nautopaedium*. The original description

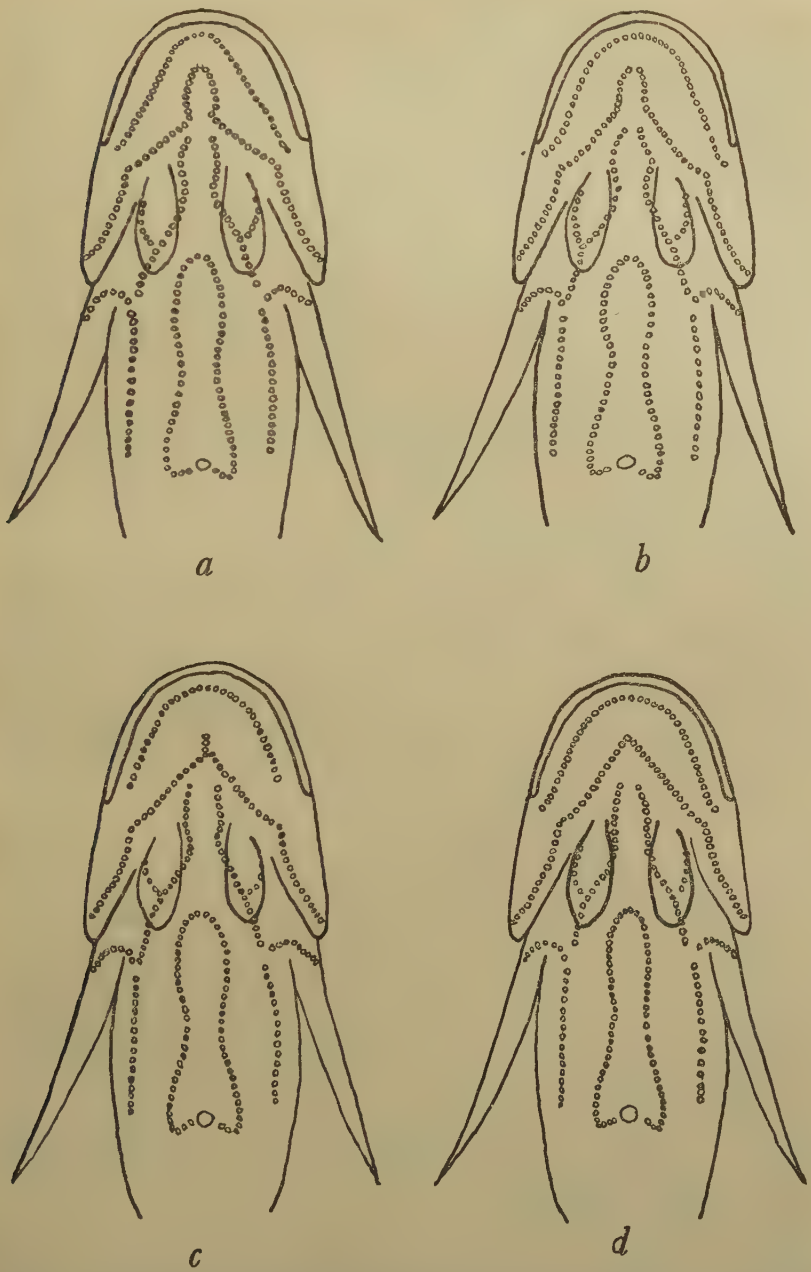

FIGURE 57.—Diagrams of the under side of the head and anterior portion of the body illustrating the courses of the photophores in : *a, Nautopaedium porosissimum; b, Porichthys myriaster; c, P. greenei; d, P. margaritatus.*

and figure of *Batrachus margaritatus* probably represent this species, although the anal rays are given as only 26 and the 8 dorsal saddles are indicated as merely dusky and as not being interspersed by smaller spots. Nor are any small spots shown on the top of the head. The marginal spots on the soft dorsal are barely indicated. In these respects this original account of *margaritatus* agrees better with the specimens discussed already as *Porichthys* species. The anal-ray count was likely an error, however, and the discrepancies in coloration are likely attributable to the small size (3.75 inches) of the type of *margaritatus*. The figure clearly shows the disconnected vertical fins and the simple V-shaped pattern of the branchiostegal photophores characteristic of *margaritatus* (also *analis* and *notatus*) as contrasted with *greenei*.

One of the best distinctions between this species and *P. notatus* lies in its longer pleural row of photophores, which, instead of ending abruptly above end of second third of anal base, is continued backward nearly to the end of the fin. This same arrangement was noted by Greene (1899, p. 676) for the 3 specimens from Alaska that he referred to *notatus*. Unless these are examples of *margaritatus* with erroneous data, they would seem to represent an undescribed species. We have seen no specimens of *Porichthys* from Alaska, and the only record for Alaska we have found is that of Sitka, given by Starks and Morris (1907, p. 230) as the northern limit of range for *notatus*.

The 6 specimens from La Paz Bay, near Cape San Lucas, agree well with the series at hand from Panama, Colombia, and Galapagos. In 3 specimens from Indefatigable Island, 65 to 89 mm long, there are about 7 bands, without intermediate dark mottlings. The dark mottlings in the vicinity of the first dorsal are inconspicuous.

The following collections of *Porichthys margaritatus* in the National Museum have been examined: U.S.N.M. nos. 41145 and 41164, from lat. 7°56′ N., long. 79°41′30″ W.[4]; 41161, Indefatigable Island[4]; 41192, La Paz Bay, Mexico; 41287, Pacific [Panama ?]; 41491 and 41492, from 7°57′ N., 78°55′ W.[5]; 101726, Pinas Bay; 101727 and 101728, Pinas Bay, north of first small island, coarse sand; 101729, Port Utria, Colombia; 101730, Port Utria, Colombia, mud; 101731, Pinas Bay, Bight of Bay, Panama, sticky mud; 101736, Gorgona Island, Colombia, near Gorgonilla Channel; 101737, north end, Gorgona Island, Colombia.

The following collections of *Porichthys margaritatus*, in the Natural History Museum of Stanford University, have been examined: No. 227, Indefatigable Island[5]; 5849, Indefatigable Island.

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[4] Listed as types of *P. nautopaedium*.
[5] Listed as cotypes of *P. nautopaedium*.

PORICHTHYS GREENEI Gilbert and Starks

FIGURE 57, *c*

Porichthys sp. GREENE, 1899, pp. 668, 678 (description of photophores in types).
Porichthys greenei *GILBERT and STARKS, 1904, pp. 184–185, pl. 30, fig. 56 (original description).—BEAN and WEED, 1910, pp. 511, 513, 515, 516, 526, figs. 3, 4, pl. 32, fig. 4 (opercular spine, pectoral fin; one of types of *Thalassophryne dowi* is this species).—*MEEK and HILDEBRAND, 1928, pp. 922, 924–925 (description, records). (Type locality: Tide pools; Panama reef.)

Should the genus *Porichthys* be further dismembered, this small species would probably be the first to be set apart, on the basis of the conjoined vertical fins, the usually simple (nonfimbriate) pores of the lateral lines, the lack of minute photophores about the pores of the dorsal branch of the lateral line, the short median branch extending forward from the apex in the branchiostegal row of photophores, and the rounded pectoral fin.

The following collections of *Porichthys greenei* in the National Museum have been examined: U.S.N.M. no. 76548, Panama Canal, Panama City; 81689 and 81690, tide pool, Panama; 81691 and 81692, tide pools, Balboa, Canal Zone; 81693, Panama Bay, Balboa, Canal Zone; 81965, Chame Point, Panama; 101732, 101733, and 101946, all from Secas Isle, Panama.

The following collections of *Porichthys greenei* in the Natural History Museum of Stanford University have been examined: No. 6485 (type), Panama reef; 6512, Panama.

Genus NAUTOPAEDIUM Jordan

Nautopaedium *JORDAN, 1919, p. 342 (diagnosis).

Orthotype.—"*Porichthys plectrodon* Jordan and Gilbert=*Batrachus porosissimus* Cuv. & Val."

We follow Jordan in distinguishing generically between the single Atlantic species and the several Pacific forms commonly referred to *Porichthys*. The prime difference lies in dentition. In *Porichthys* the palatine and premaxillary teeth as usual in fishes are directed slightly backward, whereas in *Nautopaedium* the palatine teeth are directed forward in the adults of both sexes and the posterior premaxillary teeth are directed forward in the adult male. Both the palatine and the premaxillary teeth are much more enlarged in the adult male than in *Porichthys*. The few (usually 3 to 6) developed palatine teeth are confined to the front of the bone, instead of being spread along the entire edge. Meek and Hildebrand (1928, p. 922) did not accept the genus, and we do not regard it as very trenchantly distinct.

The marked age variations and sexual dimorphism in the teeth of *Nautopaedium porosissimum* largely explain the discrepancies in published descriptions.

NAUTOPAEDIUM POROSISSIMUM (Valenciennes)

FIGURE 57, *a*

Batrachus porosissimus *VALENCIENNES, *in* Cuvier and Valenciennes, 1837, pp. 501–506 (original description; pre-Linnaean synonymy).—Jenyns, 1842, pp. 99–100 (Bahia Blanca).

Porichthys porosissimus *GIRARD, 1855a, p. 141 (new combination).—*GÜNTHER, 1861, pp. 176–177 (*margaritatus* and *notatus* as synonyms, description).—*KNER, 1865, pp. 190–191, pl. 8, figs. 1, 1a (description; Rio de Janeiro).—JORDAN and GILBERT, 1882b, p. 291 (comparison); 1883a, pp. 751–752 (description; in part).—*JORDAN, 1884a, p. 291; 1884b, p. 41; 1995b, p. 116 (teeth, range; *plectrodon* as synonym).—*MEEK and HAIL, 1885, pp. 56–57 (teeth, synonymy).—JORDAN and SWAIN, 1885, p. 545 (Pensacola, Fla.).—JORDAN, 1886, p. 229 (eaten by red snappers, Snapper Banks, Fla.).—PERUGIA, 1891, p. 620 (Montevideo).—BERG, 1895, pp. 69–70 (synonymy; in part; South American records).—REED, 1897, p. 661 (Chile by error, *fide* Delfin, 1901, p. 89).—*JORDAN and EVERMANN, 1898, p. 2319 (description, synonymy); 1900, p. 3301, pl. 335, fig. 811.—JORDAN, 1905, vol. 2, p. 526, fig. 481.—REGAN, 1914, p. 23 (off Cape Frio, Brazil).—RIBEIRO, 1915, pp. 1–4 (description; Rio de Janeiro).—DEVINCENZI, 1924, p. 258 (diagnosis; Uruguay).—*MEEK and HILDEBRAND, 1928, pp. 922–923 (description, synonymy, records).—BREDER, 1929, p. 266 (diagnosis, range). (Type locality: "De Surinam . . . Cayenne . . . Rio Janéiro . . . et de Sainte-Catherine, du Brésil"; commonly given as and hereby restricted to Surinam.)

Porichthys plectrodon GOODE and BEAN, 1882, p. 236 (*nomen nudum*; Gulf of Mexico).—*JORDAN and GILBERT, 1882b, p. 291 (original description); 1883a, p. 958 (diagnosis; South Carolina to Texas); 1883b, pp. 616, 620 (Charleston, S. C.). (Type locality: Galveston, Tex.)

The anal rays in *N. porosissimum* have been variously counted by different authors. In 24 specimens we count the dorsal and anal rays as indicated in table 4.

The following collections of *Nautopaedium porosissimum* in the National Museum have been examined: U.S.N.M. no. 30894, Galveston, Tex. (types of *Porichthys plectrodon*); 32801, Pensacola, Fla.; 39375 and 39376, lat. 28°50′ N., long. 83°00′ W., northwest end, St. Martins Reef, Fla.; 39877, off Cape Sable, Fla.; 44667 and 45995, from 10°37′40″ N., 61°42′40″ W.; 45751 and 45996, 33°20′ N., 77°05′ W., or 33°18′30″ N., 77°07′00″ W.; 47638, Alacran Shoals; 73040, off Northwest Channel, Fla., 24°40′45″ N., 81°53′40″ W.; 73041, Hawk Channel, Fla.; 73042, Pigeon Key Lake, Fla.; 73043, Pepperfish Key, Fla.; 73044, 29°48′10″ N., 83°55′15″ W.; 73045, Deadmans Bay, Fla.; 73046, off Key West, inside reef, Fla.; 73047, North Key, Fla.; 73048, Key West, Fla.; 73049, Deadmans Bay, Fla.; 73050, Pepperfish Key, Fla., 29°33′05″ N., 83°23′03″ W.; 83164 and 83168, from Rio de

Janeiro; 83833, 34°35′30″ N., 75°45′30″ W.; 83834, 34°38′00″ N., 76°12′00″ W.; 86118, Palma Sola, Fla.; 86740, coast of Uruguay; 87722, outside of bay, Rio de Janeiro; 87723, Uruguay; 87753, Santos [Barro]; 94375, off Cape Henry, Va.; 94549, Corpus Christi, Tex.; 100882, market at Santos, Brazil.

The following collections of *Nautopaedium porosissimum* in the Museum of Zoology, University of Michigan, were examined: No. 95501, Necochea, Argentina; 110159, off Englewood, Fla.; 105490, near Horn Island, Miss. (shrimp trawl).

The following collection of *Nautopaedium porosissimum* in the Natural History Museum, Stanford University, was examined: No. 9568, 10°37′40″ N., 61°42′40″ W.

TABLE 4.—*Dorsal and anal ray counts in* Nautopaedium porosissimum

Rays	Number of rays							
	31	32	33	34	35	36	37	38
Dorsal	------	------	1	4	12	5	------	1
Anal	4	11	7	1	1	------	------	----

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U. S. GOVERNMENT PRINTING OFFICE: 1938